

Rare Fossils (Conulata; Rostroconchia; Nautiloidea) from the Late Ordovician of Central New South Wales

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Manuscript received 1 December 2008, accepted for publication 16 February 2009.

KEYWORDS: Conulariid, Late Ordovician, Macquarie Arc, Nautiloid, Rostroconch

INTRODUCTION

Rare fossils, often represented by unique specimens, can sometimes be overlooked in systematic documentation of a fauna, particularly if they are not spectacular in appearance or preservation. Yet such fossils, even when fragmentary or incomplete, by their very presence can be quite significant biogeographically. Despite intensive collecting over more than thirty years (and in some cases around four decades), the examples described in this paper are the only known specimens of conulariids, a rostroconch mollusc, and a genus of tarphyceratid nautiloid that have been found in Upper Ordovician rocks of the Macquarie Arc in central New South Wales. Their uniqueness well qualifies them to be described and illustrated for the first time.

Stratigraphic setting

The Cliefden Caves Limestone Subgroup and the overlying Malongulli Formation occur in the Walli area, between Mandurama and Canowindra in central NSW (Figure 1). Outcrop of these units has

been mapped in detail south of the Belubula River by Webby and Packham (1982) in the vicinity of Cliefden Caves, and by Percival (1976) in the Licking Hole Creek area, adjoining to the west. Webby and Packham (1982) established the stratigraphic nomenclature of the Cliefden Caves Limestone Subgroup, comprising three formations (in ascending order: Fossil Hill Limestone, Belubula Limestone, Vandon Limestone), with the first and last of these subdivided into a number of members.

Conularia sp. is represented by a single specimen (described herein) collected by G.H. Packham in the late 1960s from the Taplow Limestone Member of the Fossil Hill Limestone in the section west of the "Boonderoo" shearing shed (Webby and Packham 1982, fig. 3, p.302). No other material of this species has been found in this or any other level in the Cliefden Caves Limestone Subgroup, despite intensive palaeontological investigation of the area over the past four decades. The age of the Fossil Hill Limestone is early Eastonian (Ea1), equivalent to latest Sandbian in the middle Late Ordovician. The Taplow Limestone Member was deposited in shallow

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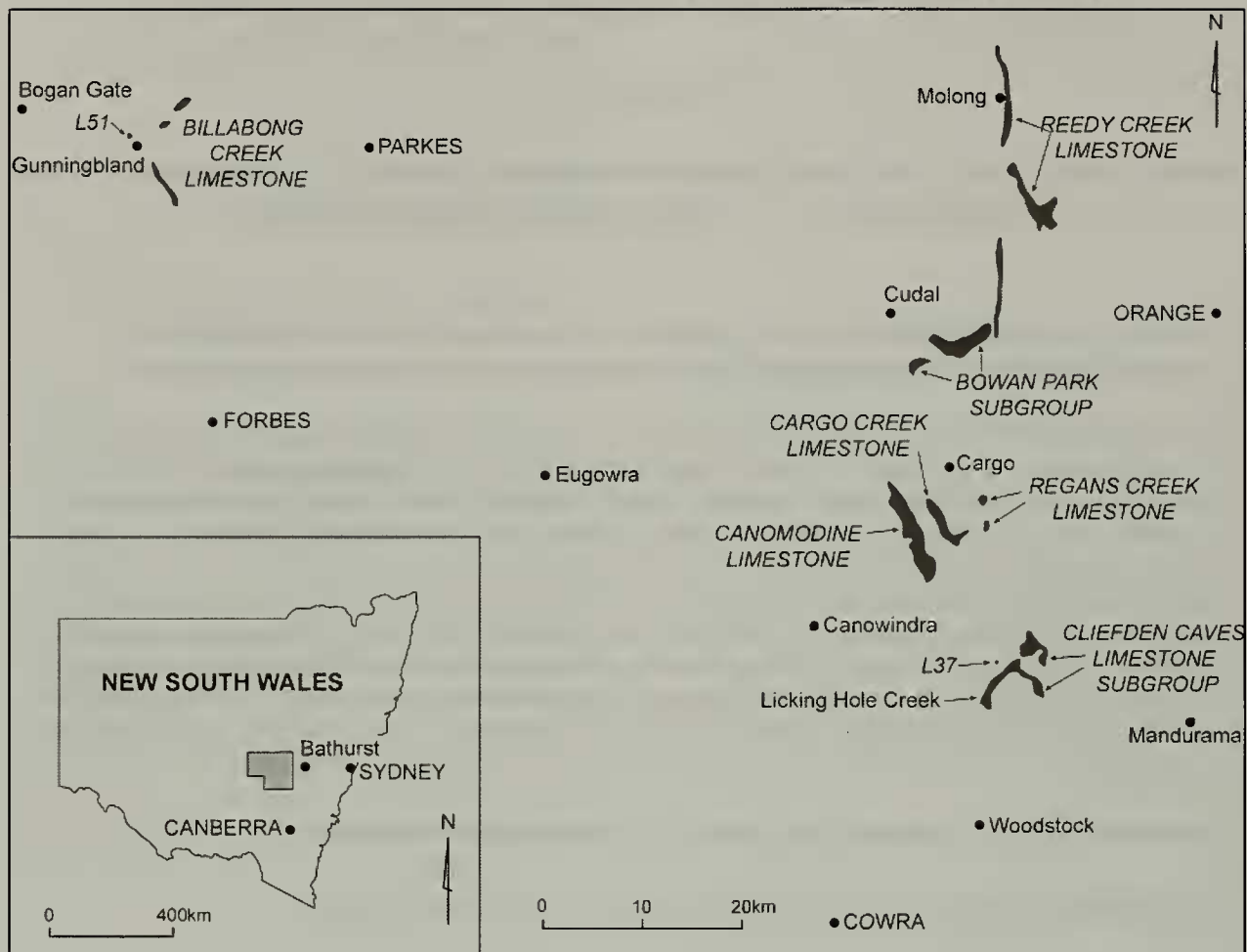


Figure 1. Locality map showing sites in central New South Wales yielding the Late Ordovician fossils described in this paper. Outcrop of main Upper Ordovician limestone units shown in black; localities (L37, L51) in overlying Upper Ordovician clastic-dominated units are shown by spots.

turbulent water interpreted as Benthic Assemblage (BA) 2 in depth (Percival and Webby 1996); the conulariid was obtained from skeletal grainstones in the middle to upper part of the member, overlying *Tetradium cribriforme* coral banks.

A solitary outcrop of allochthonous limestone at the top of the Malongulli Formation on the north-east flank of Malongulli Trig (Percival 1976) directly overlies graptolitic shale of early Bolindian age (Bo1, Zone of *Climacograptus uncinatus*), equivalent to the latest Katian stage of the Late Ordovician. A very diverse fauna – including stromatoporoids (Webby and Morris 1976), radiolaria (Webby and Blom 1986), sponge spicules (Webby and Trotter 1993), and brachiopods including lingulates (Percival et al. 1999), strophomenoids and orthoids (Percival 2005), accompanied by numerous fragments of the nautiloid *Bactroceras latisiphonatum* Glenister, 1952 (Stait et al. 1985) – is known from acid-processed

residues of the limestone. Also present in the residues are extremely rare conulariid remains, including a single microscopic conulariid specimen designated as *Microconularia fragilis* gen. et sp. nov. and fragments of a separate conulariid with distinctive pustulose ornamentation, and a unique specimen of an articulated rostroconch identified as *Eopteria* sp. which, although fragmentary, is recognizable as the first (and only) known example of this Class in the Upper Ordovician of NSW. The conulariid material and the rostroconch are described herein. The allochthonous limestone is interpreted as having been initially deposited as periplatformal ooze on the upper slope (Webby 1992) in BA 4 water depths, prior to being displaced (after lithification) downslope to its present BA 5 setting. Thus the conulariids occurring at this level lived at considerably greater depths than the larger *Conularia* sp. from the Taplow Limestone Member.

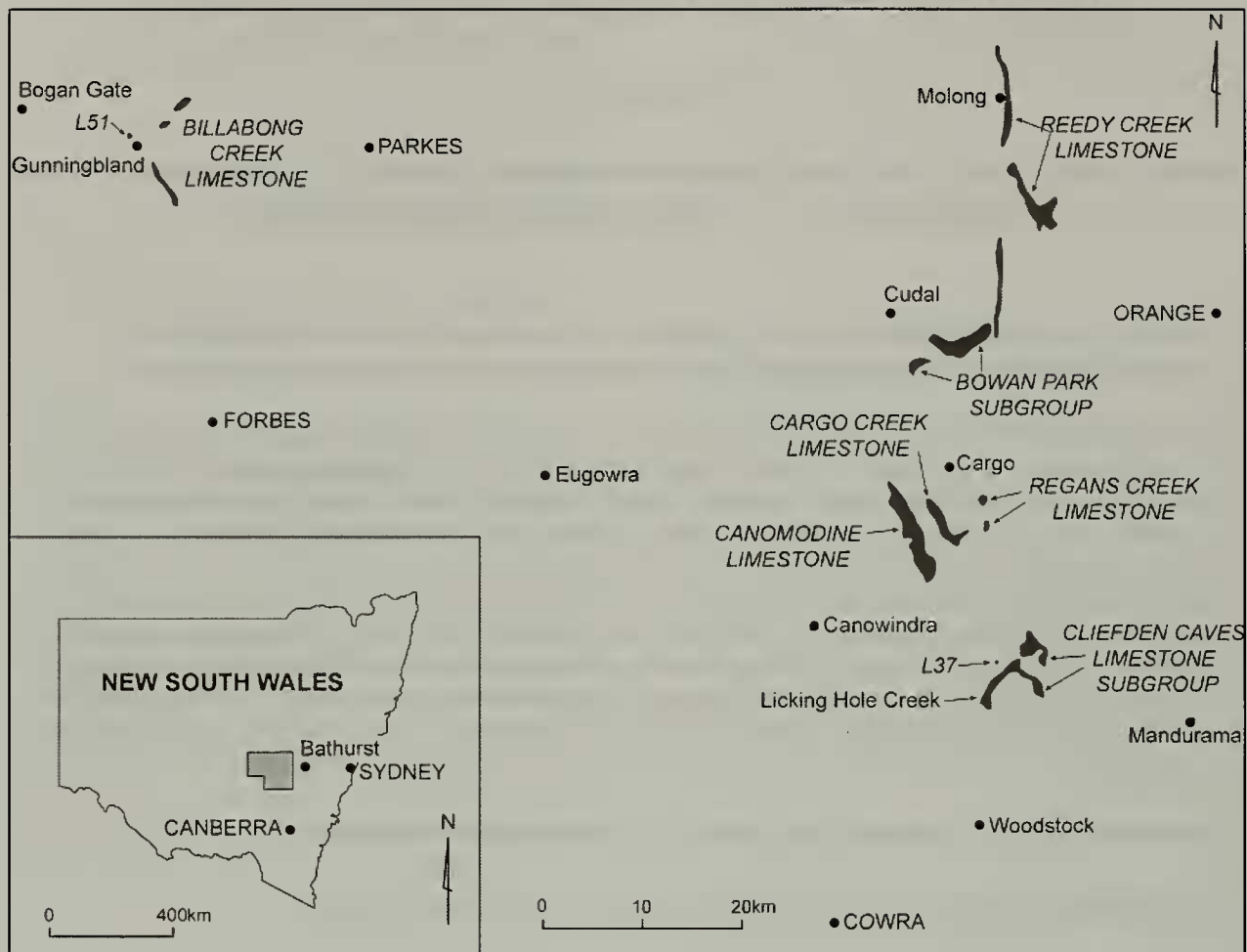


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The Bowan Park Limestone Subgroup in the area east of Cudal (Fig. 1) spans a similar age range to the Cliefden Caves Limestone Subgroup and the lower part of the Malongulli Formation, i.e. early (Ea1) to late (Ea 3-4) Eastonian, as indicated by conodonts studied by Zhen et al. (1999). The Bowan Park area was mapped in detail by Semeniuk (1973) who established the internal stratigraphy of formations and members in use today. One specimen of *Microconularia fragilis* gen. et sp. nov. is known from residues of the Downderry Limestone Member (of the Ballingoolle Limestone at the top of the Bowan Park Subgroup), which is interpreted as a submarine channel-fill deposit emplaced at water depths approximating BA 4 environments. The Downderry conulariid therefore occupied a comparable habitat to that of the conspecific example from allochthonous limestone at the top of the Malongulli Formation.

Upper Ordovician rocks in the Gunningbland area, west of Parkes on the western side of the Macquarie Arc (Pickett and Percival 2001), include the Billabong Creek Limestone (the upper part of which is correlative with the Cliefden Caves Limestone Subgroup), and the overlying clastic-dominated Gunningbland Formation which was deposited contemporaneously with the Malongulli Formation, though in slightly lesser water depths. Faunas of the Gunningbland Formation are dominated by trilobites (Edgecombe and Webby 2006, 2007) and brachiopods (Percival 1978, 1979a, 1979b, 2009). Stait et al. (1985) previously described two coiled nautiloids from this formation, including a single specimen each of *Paradiscoceras dissitum* and an indeterminate tarphyceratid. The specimen of *Plectoceras?* sp. described herein is the best preserved tarphyceratid nautiloid known from this level (a further fragmentary coiled nautiloid is documented by illustration only). These specimens, of late Eastonian (Ea3) age, equivalent to early Katian, are externally similar to slightly younger tarphyceratids documented by Percival et al. (2006).

Systematic palaeontology

Type material, comprising specimens described and illustrated or listed herein, is curated in the palaeontological collections of the Geological Survey of New South Wales (designated MMMC for microfossil specimens, and MMF for macrofossils). For brevity, authorship of taxonomic hierarchy above genus level is not cited in the References; these bibliographic sources are listed in Leme et al. (2008) for conulariids, Pojeta and Runnegar (1976) for rostroconchs, and Furnish and Glenister (1964) for tarphyceratid nautiloids.

Phylum Cnidaria

Class Scyphozoa Goette, 1887

Subclass Conulata Moore and Harrington, 1956

Order Conulariida Miller and Gurley, 1896

Suborder Conulariina Miller and Gurley, 1896

Family Conulariidae Walcott, 1886

Conularia Miller, in Sowerby 1821

Type species: *Conularia quadrisulcata* Miller, 1821

Conularia sp.

Fig. 2

Material

A single incomplete specimen, MMF 44969a-b, represented by a natural cast and an associated partial external mould.

Description

The sole specimen includes the upper two-thirds (approximately) of one individual, extending 25.1 mm in length from the top of the apertural lobes; maximum width immediately below aperture is 9.1 mm. Cross-section quadrate, profile steeply pyramidal with planar to very slightly convex faces (slightly distorted in preservation) that gently taper apically, with apical angle estimated to be 8°; apex not preserved. Ornament consists of narrow, gently arched transverse ribs (23 per cm) that are defined by pair of closely-spaced parallel ridges, separated by interspaces up to three times as broad as the ribs; interspace ridges barely visible on one face (Fig. 2I). Midline variably expressed, either as a very narrow ridge (suggestive of an internal carina) across which the transverse ribs meet in opposition (Fig. 2H), or a vertical discontinuity across which ribs alternate (Fig. 2I). Transverse ribs are almost everywhere non-tuberculate except for isolated section of one face (Fig. 2H). Corner sulcus flat-bottomed, with transverse ribs continuous between adjacent faces. Apertural lobes triangular in outline and broadly convex in profile, with continuation of midline; individual lobes are near vertical in orientation, surrounding a large open aperture. No internal features preserved.

Discussion

Conulariids are very rare in the Ordovician of Australia; only a single species has previously been described from Tasmania by Parfrey (1982), who established a new genus and species, *Tasmanoconularia tuberosa*, based on a solitary partially fragmented specimen (nevertheless with excellent surface detail) preserved in the Westfield Sandstone of the Florentine Valley. The brachiopod

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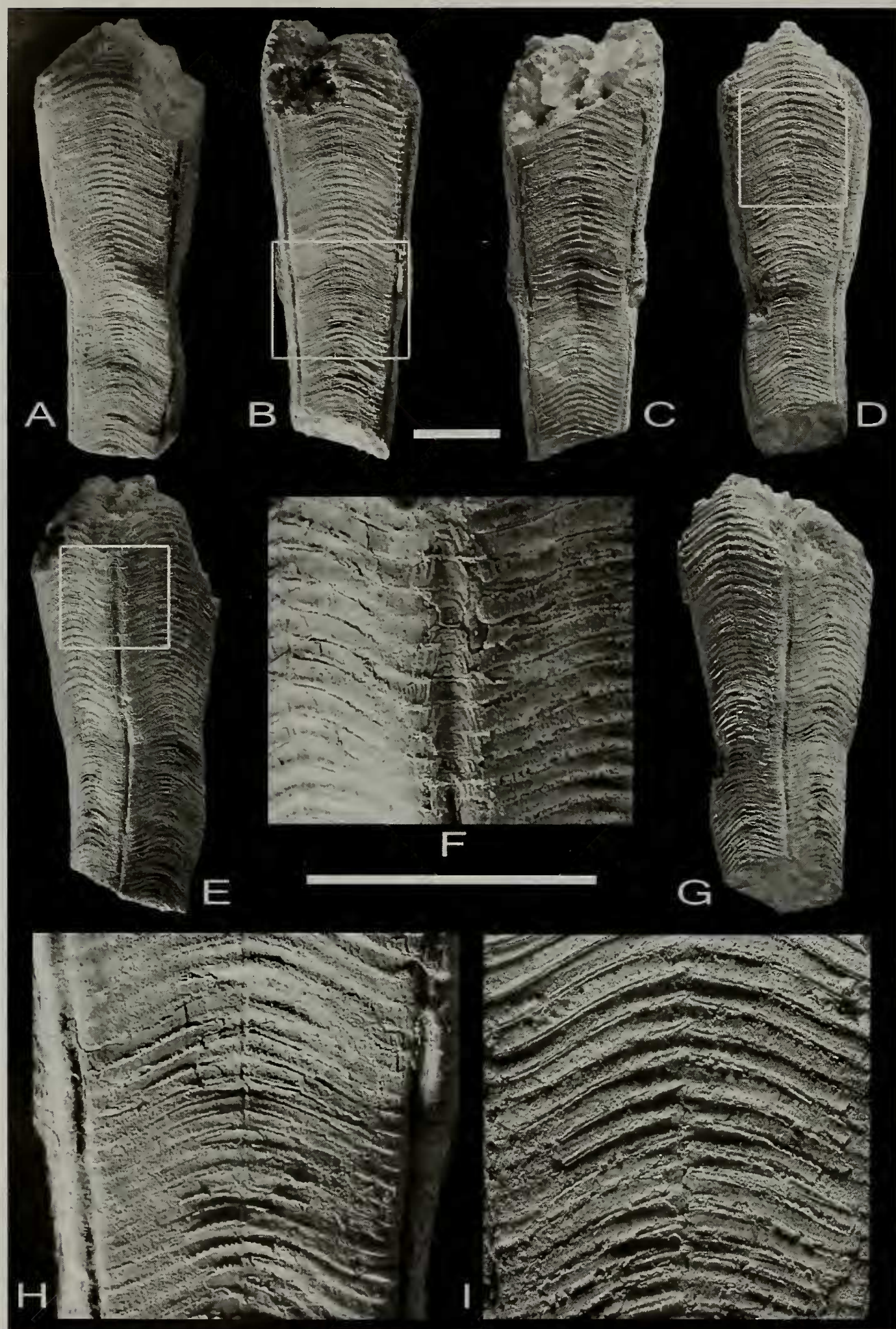
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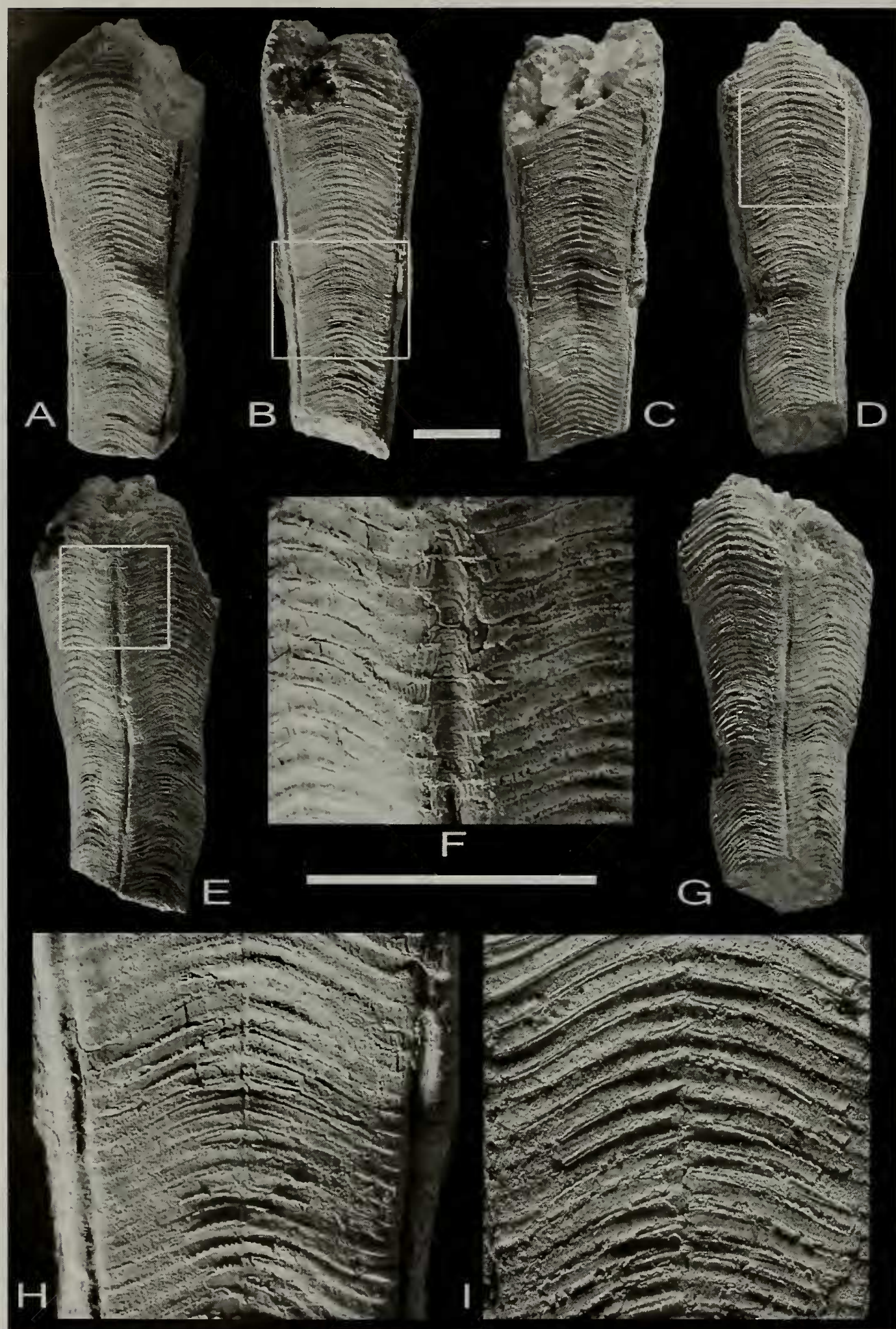
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fauna of this unit (Laurie 1991; age revised by Rong et al. 1994) contains species of *Hirnantia*, *Kinnella*, *Eospirifer*, *Cryptospira*, *Onniella?* and *Isorthis* (*Ovalella*), which are representative of the *Hirnantia* fauna of Hirnantian (latest Ordovician) age.

Parfrey (1982) distinguished *Tasmanoconularia* from *Conularia* and other genera included in the subfamily Conulariinae Walcott, 1886, by virtue of the Tasmanian conulariid having a distinct corner furrow which interrupted the continuity of the majority of transverse furrows between adjacent faces. This characteristic suggested affinities with the Paraconulariinae Sinclair, 1952. Subsequent opinion (Van Iten and Vyhlasová 2004) and cladistic analysis (Leme et al. 2008, page 652) has concluded that *Tasmanoconularia* is most likely identical with *Conularia*, with Leme et al. (2008) advocating that all previously-proposed families and subfamilies of conulariids (with the exception of the Conulariidae Walcott, 1886) be regarded as invalid.

Comparison of *C. tuberosa* (Parfrey, 1982) with *C. sp.* reveals significant differences in size and ornamentation, sufficient to easily distinguish the two forms. The Tasmanian species is considerably wider, attaining a width estimated at 15 mm in an incomplete specimen, and is much more sharply tapering towards the apex than is the NSW species. The ribs of *C. tuberosa* are crowded together (35–38 per cm) whereas those of *C. sp.* are considerably less crowded (23 per cm). Both species are finely tuberculate, *C. tuberosa* conspicuously so; although *C. sp.* appears to be almost exclusively devoid of tubercles, this is most likely an artifact of preservation, as they are present in one small area (Fig. 2H) of a face that is less weathered.

Conularia is a long-ranging cosmopolitan genus with numerous species; furthermore, the cladistic analysis of Leme et al. (2008) suggests that several other genera should probably be regarded as synonyms of *Conularia*. Comparison of the NSW species with others assigned to *Conularia* or its synonyms seems to be of doubtful value until the genus as a whole is revised. Coarsely crystalline calcite infilling the sole specimen of *C. sp.* has destroyed definitive evidence of carinae and ridges internal to the corners and midline

(although it is possible the midline is strengthened internally by a carina – see Fig. 2H). Such features are significant criteria distinguishing genera and species of conulariids (Van Iten 1992, Jerre 1994, Leme et al. 2008), and their absence hinders comparisons with established taxa.

It is appropriate here to compare *C. sp.* with Late Silurian conulariids revised or newly described from central NSW by Sherwin (1970), as these forms are closest in age and geography. *Mesoconularia webbyi* Sherwin, 1970 has an identical apical angle of 8° and generally comparable dimensions; however, transverse ribs on this species are more than twice as crowded as are those on the Late Ordovician *C. sp.*, and are always offset across the midline. *Paraconularia packhami* Sherwin, 1970, has a very similar apical angle and spacing of transverse ribs compared to the older *Conularia sp.*, but in *P. packhami* the arched transverse ribs are disjunct and apically depressed at the midline, whereas in *Conularia sp.* the transverse ridges are evenly convex toward the aperture and may be both continuous and alternating across the midline.

Distribution

Only known from the Taplow Limestone Member of the Fossil Hill Limestone, Cliefden Caves Limestone Subgroup; early Eastonian (Ea1) age, equivalent to latest Sandbian.

Microconularia gen. nov.

Type species (by monotypy): *Microconularia fragilis* gen. et sp. nov.

Diagnosis

A microscopic conulariid with non-tuberculate widely-spaced transverse ribs, lacking a midline; corners rounded, without furrows.

Discussion

Most Ordovician conulariids are more than 25 mm in length, with only two previously-described species being less than one-tenth this (Leme et al. 2003, fig. 5). Size would not normally be considered

Figure 2 (LEFT). *Conularia* sp. A – D: Four faces of internal cast, MMF 44969; E, G, views of corners of this specimen; F, detail of area of corner outlined on E, showing continuation of transverse ridges across corner sulcus; H, detail of area of face outlined on B, note minute nodes present on four transverse ridges adjacent to midline in lower part of enlargement, and continuation of majority of transverse ridges across midline; I, detail of area of face outlined on D, showing disjunct transverse ridges at midline, and suggestion of interspace ridges in upper part of enlargement. Scale bar in centre of upper row applies to A–E and G; scale bar beneath F applies only to the three enlargements. In both instances the scale bar represents five mm. From Taplow Limestone Member of Fossil Hill Limestone, near Cliefden Caves.

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as a distinguishing generic character, but in the case of conulariids there seems to be a clear dichotomy between those forms commonly found in inner and outer shelf environments in a variety of lithologies (where the overwhelming majority are macrofossils), and other taxa that are generally known only from fragmentary remains or microfossils recovered in acid-insoluble residues of limestones. The latter may range from relatively shallow to moderate water depths (BA 2-3), such as those described from Silurian limestones of central NSW (Bischoff 1973) and the island of Gotland, Sweden (Jerre 1993), to deep water (BA 4) settings as interpreted for the forms described here. One genus is less than 2 mm long, and appears to be quite distinct from many described macrofossil conulariids in lacking a definite midline, and in not developing furrows along the corners. Certainly these characteristics seem to qualify for differentiation at genus level, and hence the new genus *Microconularia* is proposed.

Teresconularia Leme et al., 2003, from the Lower Ordovician Santa Victoria Group of the Cordillera Oriental, northwestern Argentina, shares with *Microconularia* the attributes of minute size (length 1.4 mm) and rounded corners lacking a sulcus. However, the Argentine genus is considerably more widely expanding than is *Microconularia*, and the latter genus bears much coarser transverse ribs with strongly angular profiles. The ornament of *Teresconularia* is very fine and crowded by comparison. There is no evidence of a midline on the faces of *Microconularia*, whereas in *Teresconularia* a midline is present, albeit very faintly, being marked by a slight deflection of the otherwise confluent transverse ribs.

Climacocomus pumilus (Ladd, 1929), most recently described and illustrated from the Upper Ordovician Maquoketa Formation of northeastern Iowa by Van Iten et al. (1996), is another unusually tiny conulariid up to 2.5 mm in length. Although it resembles *Microconularia* in its low apical angle and coarse transverse ribs, the two genera are readily distinguished by the pronounced midline and corner sulcus of *C. pumilus*.

The maximum length of *Eoconularia loculata* (Wiman, 1895), from the Silurian Hemse Beds of Gotland, is estimated by Jerre (1994) at 10 mm, approximately 6-7 times as large as *Microconularia*. It resembles the new genus in lacking a midline, and has a similar gradually tapering shape and coarse transverse ribs. However, the presence of a corner sulcus in *E. loculata* distinguishes it from *Microconularia*. The distinctive internal septa of *E. loculata* have not been observed in the two known specimens of the new genus.

Microconularia fragilis gen. et sp. nov.

Fig. 3

Diagnosis

As for genus.

Etymology

Genus name in reference to the microscopic size of the test; species name in reference to the thin and fragile nature of the specimens.

Material

Holotype MMMC 4388 from L37, allochthonous limestone at top of Malongulli Formation, head of Sugarloaf Creek on northeast flank of Malongulli Trig, near Cliefden Caves; paratype MMMC 4389, a fragmentary specimen from the same locality as the holotype; paratype MMMC 4390 from Donderry Limestone Member of the Ballingool Limestone, Bowan Park Subgroup, near Malachis Hill at Bowan Park.

Description

Test minute, less than 2 mm in length, very gradually tapering with apical angle of the order of 1-3°; cross-section quadrate, with flat to slightly concave faces ornamented with relatively coarse

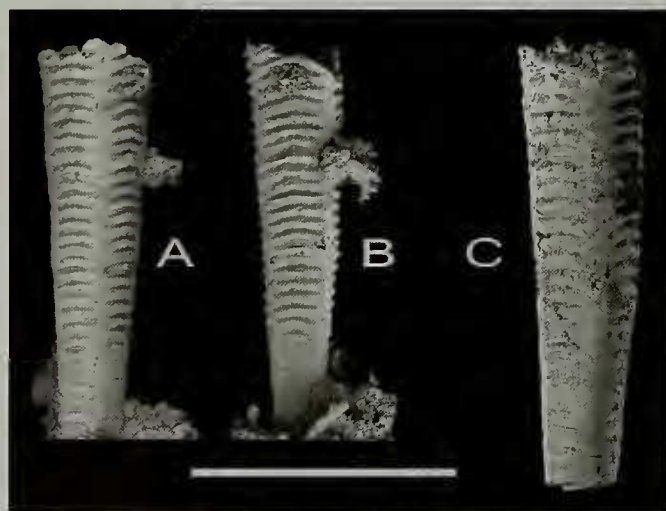


Figure 3. A – C. *Microconularia fragilis* gen. et sp. nov. A – B: Holotype, MMMC 4388, view showing corner, and lateral view of face. C: Paratype MMMC 4390. Scale bar represents one mm. Holotype from locality L37, allochthonous limestone at top of Malongulli Formation on flank of Malongulli Trig; earliest Bolindian (Bo1) age. Specimen C from Donderry Limestone Member of the Ballingool Limestone, Bowan Park Subgroup, near Malachis Hill at Bowan Park, late Eastonian (Ea3) age.

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Microconularia fragilis gen. et sp. nov.

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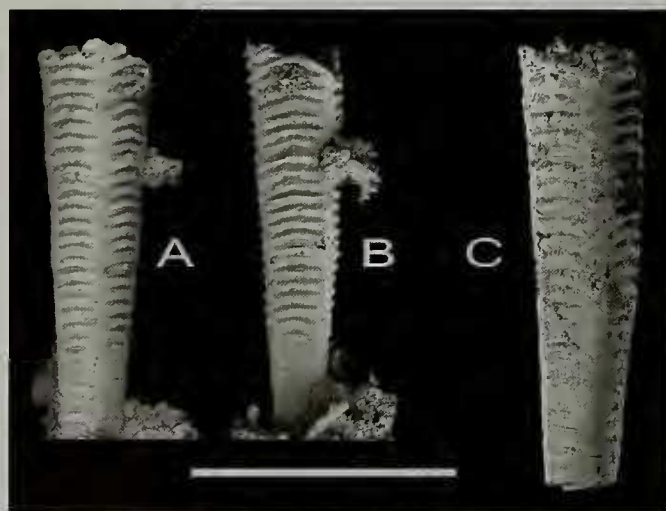


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widely and evenly spaced transverse ribs separated by interspaces of similar length; 14-19 ribs per mm; ribs have angular profile (where not eroded) and are gently and evenly arched; midline lacking. Corners of test rounded without any furrow; transverse ribs from adjacent faces are not continuous around corners, but appear to be offset and alternate so that a rib passes abruptly into an adjacent interspace. Apertural lobes and apex not preserved in available specimens. Internal features unknown.

Dimensions

Holotype MMMC 4388: length 1.5 mm, maximum width 0.3 mm.

Paratype MMMC 4390: length 1.7 mm, maximum width 0.4 mm

Discussion

This exceptionally rare conulariid is represented

in two localities, both in allochthonous limestones of BA 4 original depositional depth (inferred on the basis of associated faunas) that have been redeposited downslope. Age of these horizons is reasonably contemporaneous (late Eastonian to early Bolindian).

Distribution

Deepwater strata of late Eastonian (Ea3-4) to earliest Bolindian (Bo1) age, equivalent to Katian Stage, in central NSW.

Metaconularia Foerste, 1928

Type species: *Conularia aspersa* Lindström, 1884

Metaconularia? sp.

Fig. 4

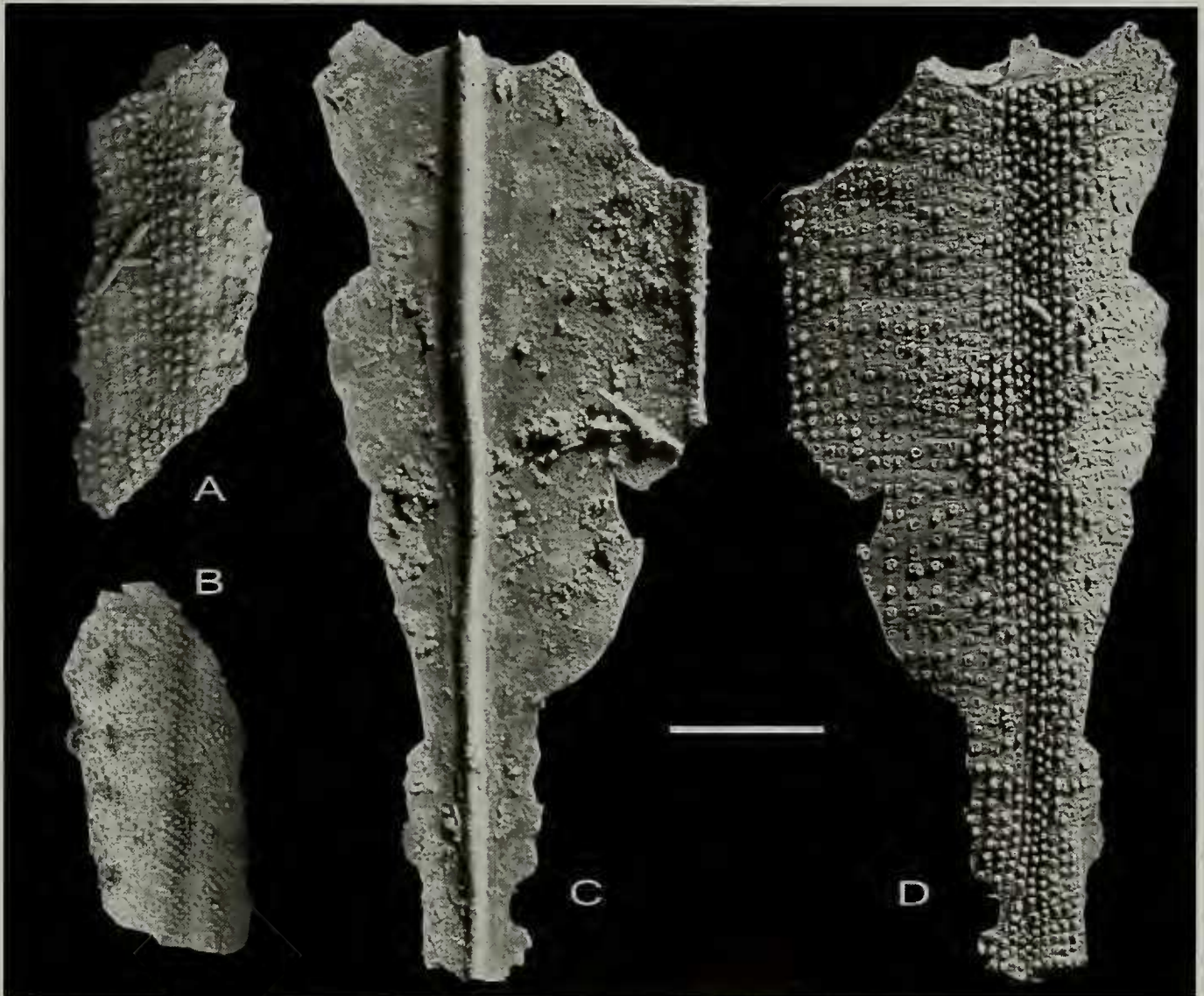


Figure 4. A – D *Metaconularia*? sp. A: exterior fragment, MMMC 4391. B: exterior fragment, MMMC 4392. C – D: interior and exterior of fragment, MMMC 4393. Scale bar represents one mm. All specimens from locality L37, allochthonous limestone at top of Malongulli Formation on flank of Malongulli Trig; earliest Bolindian (Bo1) age.

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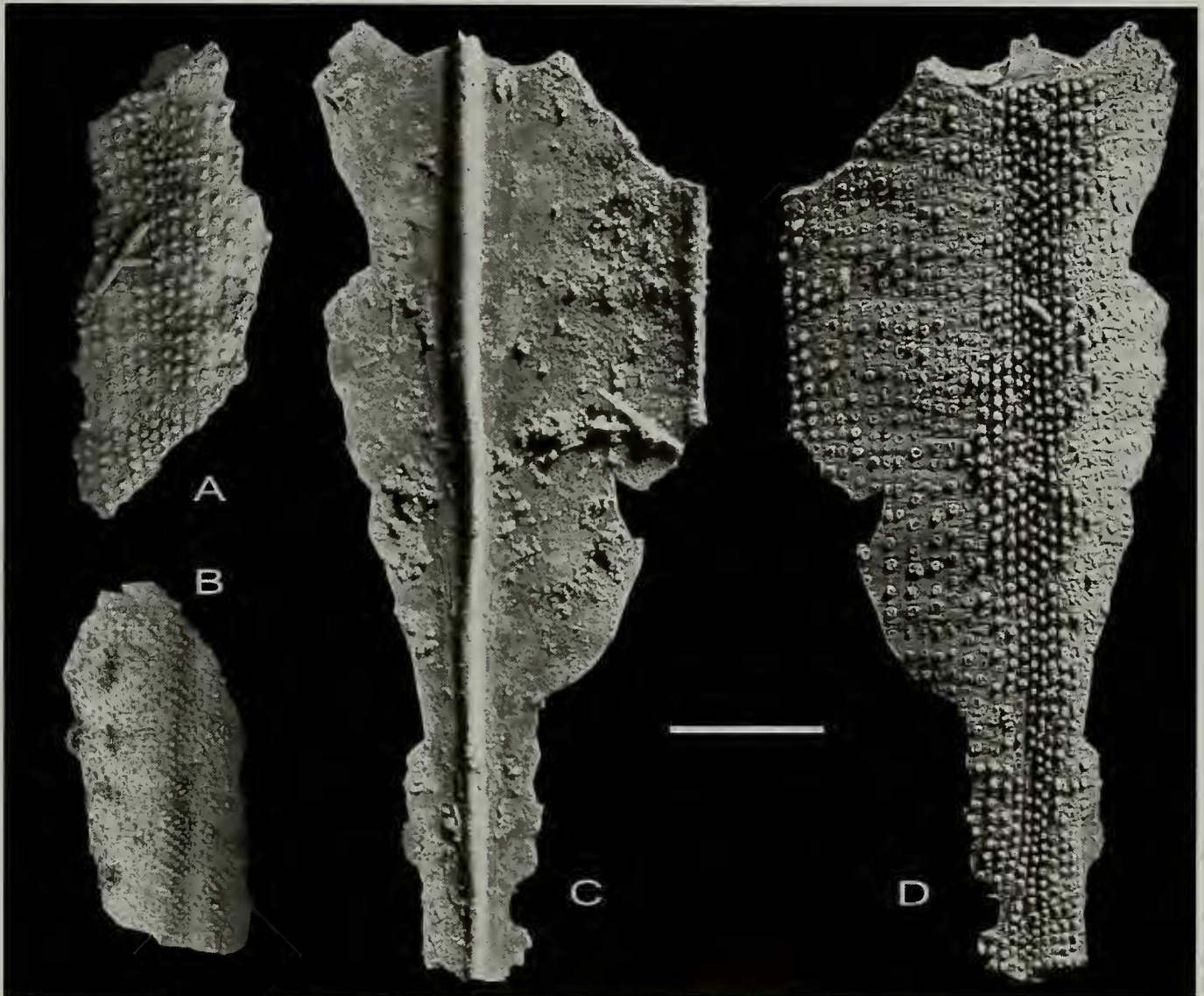


Figure 4. A – D *Metaconularia*? sp. A: exterior fragment, MMMC 4391. B: exterior fragment, MMMC 4392. C – D: interior and exterior of fragment, MMMC 4393. Scale bar represents one mm. All specimens from locality L37, allochthonous limestone at top of Malongulli Formation on flank of Malongulli Trig; earliest Bolindian (Bo1) age.

Material

Fragments with tuberculate ornamentation are uncommon in residues of acid-etched limestones at locality L37, allochthonous limestone at top of the Malongulli Formation, head of Sugarloaf Creek on northeast flank of Malongulli Trig, near Cliefden Caves. Three representative specimens, MMMC 4391 – 4393, are illustrated.

Description

All material consists of incomplete fragments of the test, displaying distinctive coarse and fine tuberculate ornamentation on the exterior surface. The fragments are flat to gently convex, sometimes bearing shallow sulci or furrows, and presumably represent portions of the faces of the theca. Largest fragment observed is 6.3 mm in length. Tubercles are irregularly distributed, generally crowded along shallow furrows in the shell surface (occasionally, a furrow is underlain by a septum on the interior surface of the test) and more scattered on the flanks adjacent to the furrows. A subtle to moderately strongly expressed longitudinal and transverse arrangement of the tubercles into columns and rows is often discernable; the rows may be oblique (Fig. 4B) or perpendicular (Fig. 4D) to the main axis of the specimen. Many (if not all) of the tubercles are hollow, observable where the tips have been eroded. Transverse ridges and interrods are lacking, and sharply defined midlines are not present. Corners between faces are unknown in the available material. Internal septa are low narrow linear features, not twinned; remainder of interior surface is smooth.

Discussion

The tuberculate ornament and absence of transverse ridges on the faces readily distinguishes these fragments from specimens of *Microconularia* with which they are associated in the acid-etched residues. Where septa are present internally, their surficial expression is a crowding of tubercles along a shallow linear depression or furrow; there is no development of a deep narrow midline such as is seen in conulariid fragments from the Silurian age Boree Creek Formation of central NSW (Bischoff 1978, pl. 1, fig. 11a-b).

Jerre (1993) discussed and figured several conulariid fragments with comparable tuberculate ornamentation that he referred to *Metaconularia aspersa* (Lindström, 1884) from the Silurian of Gotland. Bischoff (1973) also recognized similar fragments from both Silurian (Bischoff 1973, pl. 2, figs. 15 and 17) and Ordovician (pl. 3, fig. 11) horizons, but did not attribute these to genera. *Metaconularia*

ranges from the Middle and Late Ordovician (Van Iten and Vyhlásová 2004, fig. 14.1) through the Silurian (Leme et al. 2008). The specimens from NSW are too incomplete for definitive identification, so they are tentatively assigned to *Metaconularia* pending collection of more entire material.

Distribution

Recovered only in residues of allochthonous limestone at top of Malongulli Formation; earliest Bolindian (Bo1) age, equivalent to Katian.

Phylum Mollusca Cuvier, 1797

Class Rostroconchia Pojeta, Runnegar, Morris and Newell, 1972

Order Conocardioidea Neumayr, 1891

Superfamily Eopterioidea Miller, 1889

Family Eopteriidae Miller, 1889

Eopteria Billings, 1865

Type species: *Eopteria typica* Billings, 1865

Diagnosis

Eopteriid with a prominent anterior snout that lacks radial ribs (Pojeta et al. 1977, p. 26).

Eopteria sp.

Fig. 5

Material

Figured specimen MMF 44970a, comprising a fragmentary pair of silicified conjoined valves. Several shell fragments definitely attributable to this specimen were also picked from the same limestone residue, as was the isolated posterior extremity MMF 44970b here figured (Fig. 5C). Although the latter cannot with certainty be assigned to the main specimen due to absence of intervening shell, there is a very high probability that it was broken from that specimen.

Description

Valves moderately biconvex, maximum length at hingeline; inflated medial third of valves extends from prominent umbo to ventral margin, and bears about a dozen rounded radial ribs spaced 2-3 per mm; raised ribs not present on snout, which instead bears shallow radial grooves becoming more widely spaced towards anterior extremity. Posterior third of valves also marked with shallow radial grooves. Faint closely spaced concentric growth lines are present on anterior and posterior flanks. Few internal features visible due to fragmentary preservation; however, a prominent

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Figure 5. A – C *Eopteria* sp., conjoined specimen MMF 44970. A: left valve; B: right valve; C: fragment of posterior, viewed slightly obliquely. Scale bar represents one mm. Specimen from locality L37, allochthonous limestone at top of Malongulli Formation on flank of Malongulli Trig.

internal ridge is present on the interior of the right valve, trending anteroventrally to intersect the valve margin. Internal shell surface smooth. Presence of pegma not verifiable.

Dimensions

The specimen is incomplete, with length of 6.7 mm, and height of 6.0 mm. The separate posterior extremity is 2.1 mm in length. Estimated maximum dimensions of the complete individual would be 6–7 mm in height, and at least 9–10 mm in length.

Discussion

This was the specimen from NSW referred to by Popov et al. (2003, p.177, pers. comm. by I.G. Percival), in discussion of the palaeogeographic setting of their new species *Eopteria aiteneria* from the Late Ordovician (Hirnantian) Angrensor Formation of north-eastern central Kazakhstan. That species was also described from a single damaged shell, though it is more complete than the NSW specimen which is of almost identical dimensions. However, the two are not conspecific, the most significant point of difference between them being the characteristic lunulate comarginal ornament developed on the anterior snout of *E. aiteneria*. The anterior snout of the NSW species instead bears several shallow radial grooves that possibly define a series of flattened wide ribs progressively decreasing in amplitude away from the inflated umbo. The medial strongly ribbed part of *E. aiteneria* is sharply bounded by carinae, particularly posteriorly, whereas the NSW species is more evenly rounded with a relatively gradual change in slope from the median region to the adjacent flanks.

The presence of an internal ridge in the right valve of *E. aiteneria* cannot be verified as the interior of this species is unknown.

The only other known Late Ordovician species of *Eopteria* is *E. conocardiformis* Pojeta and Runnegar, 1976 from the Little Oak Formation of Alabama and the High Bridge Group of Kentucky, which is characterized by an elongation of the anterior snout. It also appears to be considerably more inflated than the species from NSW. Cope (2004) assigns an early Late Ordovician (Sandbian equivalent) age to this species. Thus *Eopteria* sp. from NSW, of late Katian age, is significant in partly bridging the gap between the Laurentian and Kazakhstan occurrences, where previously no species referable to this genus were known (Cope 2004, fig. 20).

Although *Eopteria* sp. can be readily distinguished from these Late Ordovician (and older) species, it would be unwise to establish a new species based on such fragmentary material, and so the specimen is left in open nomenclature.

Distribution

Recovered only in residues of allochthonous limestone at top of Malongulli Formation at locality L37; earliest Bolindian (Bo1) age, equivalent to late Katian.

Class Cephalopoda Cuvier, 1797
Subclass Nautiloidea Agassiz, 1847
Order Tarphycerida Flower, in Flower and Kummel, 1950
Family Plectoceratidae Hyatt, 1894



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RARE FOSSILS FROM THE LATE ORDOVICIAN

Genus *Plectoceras* Hyatt, 1894

Type species: *Nautilus jason* Billings, 1859

Plectoceras? sp.

Fig. 6

Material

Specimen MMF 44971, represented by a composite cast, mostly decorticated; this specimen was longitudinally sectioned for study.

Description

Conch exogastric, planispiral, tightly coiled with three whorls all in contact, gently expanding from 6-7 mm height in inner whorls to attain 16.5 mm in height at body chamber which is approximately 21 mm in length; whorl expansion rate (WER) 1.78. Exterior with moderately coarse rounded ribs directed apicad and forming a wide V-shape at midline; 3-4 ribs in 10 mm. Chambers are rounded subquadrate in cross section, moderately inflated and gently impressed

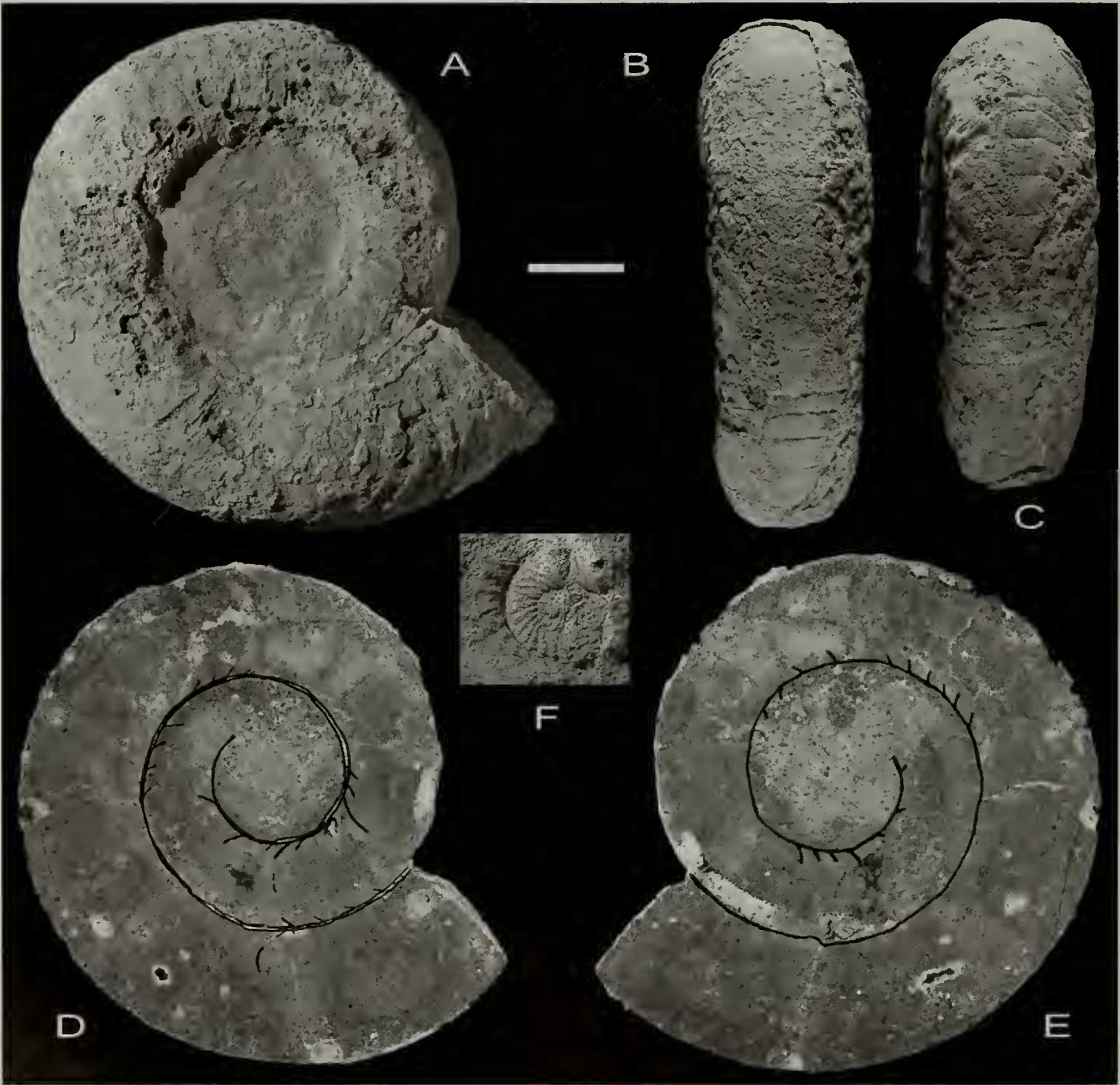


Figure 6. A – E *Plectoceras?* sp., MMF 44971. A – C: conch (prior to sectioning) in lateral view, and two whorl profiles (slightly rotated) showing ornament and camerae; D – E: longitudinal section through conch, D off-centre, and E sagittal, with internal features inked-in for clarity. Note in E, remains of sip-huncle (ventral in position) infilled with calcite immediately above body chamber. F. fragment of exterior of indeterminate tarphyceratid nautiloid, MMF 44972. Scale bar represents one cm. Both specimens from Gunningbland Formation at locality L51, “Currajong Park”, Gunningbland.

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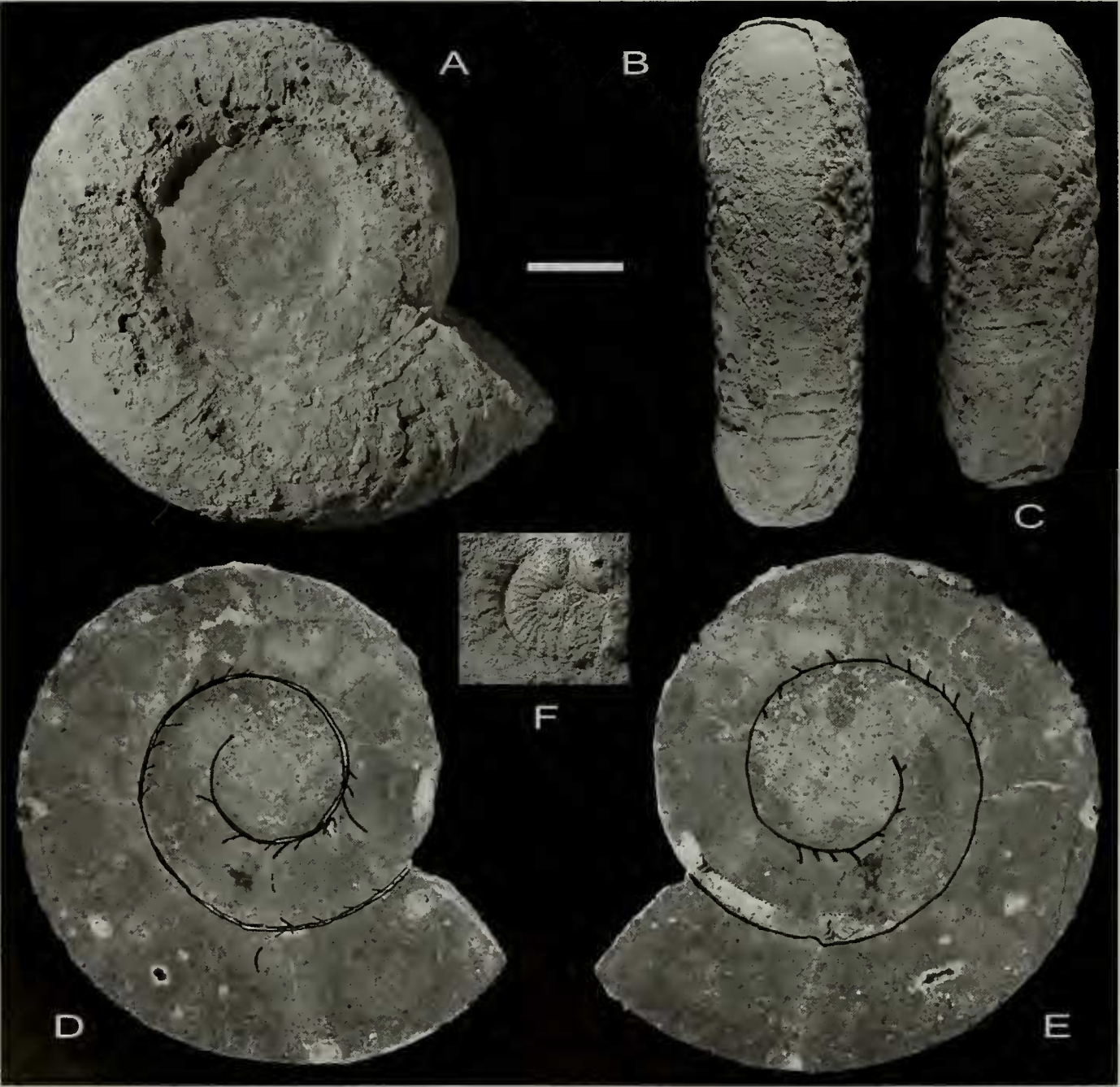


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dorsally. Camerae behind body chamber gently flexed towards aperture and spaced up to 4.3 mm apart, narrowing to about 2 mm apart in inner whorls where they extend straight across venter. Siphuncle only partly visible as a calcite-filled tube with diameter of 2.4 mm, ventral and marginal in position; septal necks and connecting rings not preserved.

Dimensions

Maximum diameter of conch 60 mm; width of body chamber 20.0 mm.

Discussion

Due to its poor internal preservation, with septal necks absent and the siphuncle inadequately preserved, identification of this specimen to genus level remains tentative at this time pending the discovery of additional better-preserved material. The ventral position of the siphuncle and strongly ribbed coiled conch invites comparisons with tarphyceratids. Of Middle to Late Ordovician genera, the most similar to the Gunningbland specimen appears to be *Plectoceras*, which is represented by numerous species in North America. Frey (1995) observed that these species fell into two major groups, one comprising forms that are generally smaller in diameter in which the whorls remain in contact, contrasting with the second group of generally larger conchs (including the type species) in which the final whorls became disjunct. Affinities of the Gunningbland species lie with the first of these species groups.

The relatively low WER is also similar to that of *Tarphyceras*, but that predominantly Early Ordovician genus is typically nearly smooth externally (B. Kröger, pers. comm.). Two species of ribbed coiled nautiloids of latest Ordovician (Hirnantian) age from the Morkoka River region of the Siberian Platform were identified as *Tarphyceras*? by Balashov (1962). Illustrations of one of these, *T? morkokense* Balashov, 1955, clearly show a ventral submarginal siphuncle. Dimensions of the type specimen (Balashov 1955, pl. XLIII fig. 3a-b; refigured by Balashov 1962, pl. XLVI fig. 3) are very similar to those of *Plectoceras*? from Gunningbland.

Stait et al. (1985, fig. 10) documented an incomplete external cast of a strongly ribbed coiled nautiloid from immediately overlying beds in the Gunningbland Formation, which, in the absence of any internal features, could only be referred to an indeterminate tarphyceratid. This specimen is very possibly congeneric with the one described here as *Plectoceras*? as it shares comparable dimensions and external features. An additional fragmentary exterior of a similar unidentified coiled nautiloid with coarse

ribbing is illustrated (Fig. 6F). Slightly younger tarphyceratids, again with prominent ribs, have been found in the Jingerangle Formation (of early Bolindian age, i.e. latest Katian) near Quandialla, about 95 km south of Gunningbland (Percival et al. 2006), but as all are preserved as moulds the position of the siphuncle and other internal features is unknown.

Distribution

Gunningbland Formation (upper part), "Currajong Park" property at Gunningbland; late Eastonian (Ea3-4), equivalent to early Katian.

ACKNOWLEDGMENTS

Without permission from landholders to collect specimens from their properties, none of these rare fossils would ever have come to light; for allowing access I thank the Dunhill family of "Boonderoo", the McLarens of "Liscombe Pools", and John and Julie Rhodes, former owners of "Sunnyside". Technical assistance provided by Gary Dargan (NSW Department of Primary Industries) enabled preparation of the polished section of the tarphyceratid nautiloid from Gunningbland. I am grateful to Sue Lindsay (Australian Museum, Sydney) for facilitating SEM imaging of the microconulariids. David Barnes (NSW DPI) expertly prepared the photographic illustrations, and Cheryl Hormann (NSW DPI) drafted Figure 1. Heyo Van Iten, Björn Kröger and Leonid Popov provided very helpful advice on the identifications of the conulariids, nautiloid and rostroconch respectively. Reviews by two anonymous referees of the entire manuscript were most useful in fine-tuning it for publication. This paper is a contribution to IGCP Project No. 503: Ordovician Palaeogeography and Palaeoclimate. Published with the permission of the Director, Geological Survey of New South Wales, NSW Department of Primary Industries.

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dorsally. Camerae behind body chamber gently flexed towards aperture and spaced up to 4.3 mm apart, narrowing to about 2 mm apart in inner whorls where they extend straight across venter. Siphuncle only partly visible as a calcite-filled tube with diameter of 2.4 mm, ventral and marginal in position; septal necks and connecting rings not preserved.

Dimensions

Maximum diameter of conch 60 mm; width of body chamber 20.0 mm.

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Due to its poor internal preservation, with septal necks absent and the siphuncle inadequately preserved, identification of this specimen to genus level remains tentative at this time pending the discovery of additional better-preserved material. The ventral position of the siphuncle and strongly ribbed coiled conch invites comparisons with tarphyceratids. Of Middle to Late Ordovician genera, the most similar to the Gunningbland specimen appears to be *Plectoceras*, which is represented by numerous species in North America. Frey (1995) observed that these species fell into two major groups, one comprising forms that are generally smaller in diameter in which the whorls remain in contact, contrasting with the second group of generally larger conchs (including the type species) in which the final whorls became disjunct. Affinities of the Gunningbland species lie with the first of these species groups.

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